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METHANOL

Chasing an elusive fuel market Page 9

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Cover: First factory-produced methanol-fueled bus operates daily as joint demonstration project of Golden Gate Transit District (San Francisco) and California Energy Commission. Photo courtesy of Celanese, which provides methanol fuel and engineering backup

News Focus

Methanol producers in U.S. must contend with overcapacity, import competition until the long-awaited fuel market bonanza arrives. **Page 9**

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Large-Volume Fuel Market Still Eludes Methanol

Problems delaying development of potentially huge market mean U.S. producers must live with overcapacity, import competition, and little profit

Earl V. Anderson, C&EN New York

Du Pont applied to the Environmental Protection Agency last week for a Clean Air Act waiver that would allow the firm to blend up to 5% methanol and a minimum of 2.5% cosolvent alcohol with unleaded gasoline.

EPA denied a similar Du Pont waiver request last year because, according to EPA, there weren't enough evaporative emissions data. A Du Pont spokesman vowed that the company would not submit another request until it was positive that it would be accepted. Based on the research and testing that went into the new effort, it seems likely that, this time, Du Pont's waiver request will sail through.

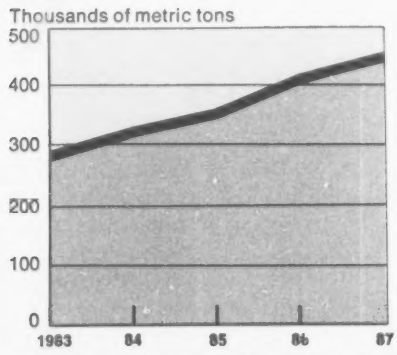
If it does, it will be the first really good news for a beleaguered U.S. methanol industry in some time. And U.S. producers can use some good news, because they are squarely between a rock and a hard place.

The rock might be regarded as serious overcapacity and only slowly rising demand. In the U.S., and throughout the world, there is much more methanol capacity than consumers can possibly use—and more is on the way. Traditional chemical markets for methanol are mature, and thus growing slowly. Together, they are not soaking up all the methanol now available, not to mention the new capacity that hasn't started up yet. And even though exciting new uses await methanol in C_1 chemistry, these are a long way down the road. They will provide little relief for methanol producers until the 1990s. In the meantime, the world methanol situation is posing challenges for process designers (see page 31).

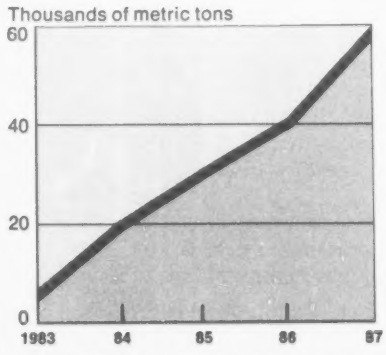
The hard place is the fuel market. This market was, and still is, the great hope of companies with too much methanol and not enough places to sell it. But the fuel market is proving to be a hard, and elusive,

How U.S. methanol demand will grow

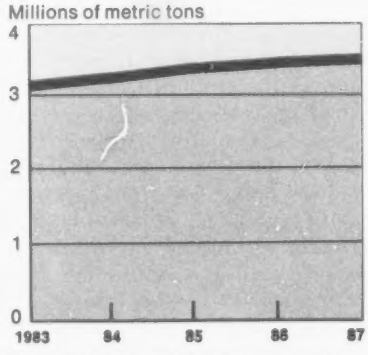
Faster as blends with gasoline . . .



. . . and as neat fuel . . .



. . . than in traditional chemical markets

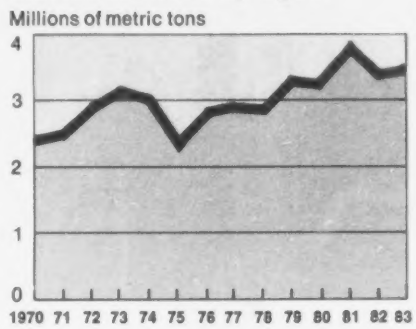


Note: Neat fuel is 100% or near 100% methanol. Traditional chemical markets include formaldehyde, solvents, acetic acid, methyl halides, methyl methacrylate, methyl amines, and dimethyl terephthalate. Methyl *tert*-butyl ether is not included. **Source:** DeWitt & Co.

place indeed. Despite all the attractions of methanol as an alternative fuel, the market is proving to be much tougher to crack than most producers imagined when they first geared up for an assault on gasoline's domain.

Estimates are difficult to pinpoint and they range all over the place, but probably less than 300,000 metric tons of methanol—about 8% of total U.S. consumption—went into fuels last year, after years of knocking on the door. That doesn't include the methanol that went into the octane extender, methyl *tert*-butyl ether (MTBE).

Methanol production has started to move up again



Source: International Trade Commission

The biggest problem, of course, is that energy economics have changed dramatically in recent years. In 1979 motorists in the U.S. and other oil-dependent nations suffered through their second oil crisis with its sharply curtailed supplies, painfully higher prices, and long lines at the gas pumps. At the time, alternative fuels became the order of the day. World attention focused on methanol.

Almost universally, the experts warned that crude oil prices would rise continuously. They warned that supplies could be tight for a long time, that disruptions were inevitable.

But the oil market crossed up the experts and almost everybody else. Energy conservation and a worldwide recession with its lower energy demand brought the rapid-fire increases in crude prices to a screeching halt. Now there is a glut in the world crude market and, barring a major political or military upheaval, crude prices are expected to rise only in line with inflation for the remainder of the decade. With smaller cars and their improved fuel efficiency, U.S. gasoline demand peaked in 1979. The sense of urgency that gripped alternative fuels five years ago has diminished, if not disappeared.

This new energy economics picture is perhaps the biggest, but certainly not the only, obstacle facing methanol's advance into fuels. Major oil companies aren't particularly happy about sharing their gasoline market with methanol. Several of them have launched heated campaigns to discredit methanol as a fuel. A flurry of "overblending" cases has triggered a stream of bad-press reports about methanol and the damage it has caused auto engines and other auto parts. Regulations—those now in place and some that are needed—create additional problems.

Although these and other problems are making it difficult for methanol producers to crack the fuel market in a big way, the companies haven't stopped trying. The prize—an immense outlet for their surplus methanol—is too valuable for them to give up on it. They are approaching the fuel market from every avenue possible, through neat (or nearly 100%) methanol, blends of methanol with unleaded gasoline (with or without a higher alcohol cosolvent), or via octane enhancers such as MTBE. In New Zealand, Mobil's direct MTG (methanol-to-gasoline) process is getting into the act. Almost everyone agrees that a neat methanol fuel system is the ultimate goal. This route avoids many of the problems created by methanol blends (which blend enthusiasts correctly argue can be overcome). The volumes involved in a neat methanol fuel market would be tremendous. Excess capacity would be used up in a hurry. More plants, in fact, would be needed.

But neat methanol fuel presents its own dilemma: Which should be developed first—supplies and a vast distribution system, or cars that will operate on methanol? Nobody seems willing to be first in making the huge investments necessary to make a neat methanol system work. On the supply side, a revamped distribution system would be necessary. But producers and distributors don't want to take the plunge until there is an assured market in the form of cars that can run on methanol. Automakers, on the other hand, don't want to pay the price of retooling for methanol cars until they are sure that their customers can find the methanol to fuel them. The result: investment paralysis.

So far, neat methanol hasn't made much of an impact on the fuel market. That market is limited to California, where extensive fleet tests have been under way for some time, and to a few other scattered test fleets. California is a leading champion of neat methanol, but last year probably no more than 5000 metric tons went into the fuel market as neat methanol.

Many experts feel that the dilemma facing neat methanol can't be solved by a freely operating marketplace alone. They say that the federal government will have to play a bigger role in developing a neat methanol market, just as the state government in California already is doing. In Washington, D.C., both Congress and the White House have taken a renewed interest in methanol, but what will come out of their efforts, and when, is difficult to predict.

Until government action or something else can break the impasse that haunts neat methanol fuel, most of the action—and most of the controversy—is taking place in methanol blends.

In the U.S. about 280,000 metric tons of methanol was blended into gasoline last year, along with higher alcohols as cosolvents, according to James R. Crocco, vice president of DeWitt & Co., Houston. Other estimates put the hard-to-pinpoint volume at twice that amount. Either way, it's nowhere near the quantity that methanol producers have been hoping for.

Methanol blends do have advantages. With methanol now costing about 42 cents per gal, and gasoline costing $1.20 or so per gal, the economics look good.

It's possible to use low percentages of methanol in unleaded gasoline with little or no modification to conventional cars. And blend advocates see it as a way to get the driving public tuned in to methanol until neat methanol becomes more widely accepted.

But blended methanol has its handicaps as well. Detroit isn't particularly enthusiastic about methanol blends. Some auto makers have threatened to void their new-car warranties if the cars are run on methanol-blended fuel. And some unscrupulous blenders, with an eye toward improving their profit margin, have illegally overblended methanol into unleaded gasoline. The resulting "horror stories" in the press about drivability problems and engine damage have given methanol blends a bad name and have made it more difficult for honest blenders to market their fuel. Some major oil companies, concerned about methanol's infringing on their gasoline market, also have spread the word about blended methanol's misfortunes and disadvantages.

Perhaps blended methanol's biggest technical disadvantage is its moisture problem. Even minute amounts of moisture destabilize the methanol-gasoline mixture. Metal corrosion becomes a serious problem when phase separation occurs. That's where cosolvents come in. When heavier alcohols are added to methanol, its water tolerance improves markedly.

On the regulatory end, methanol blends require an EPA waiver from the provisions of the Clean Air Act. Section 211(f) of that act prohibits selling new unleaded fuels, or fuel additives in unleaded fuels, without EPA approval. EPA will grant waivers if it is satisfied that the fuel or additive will not cause violations of vehicle emission standards.

Several methanol waivers have been granted, and several have been denied. Sun Oil Products received a waiver for an additive consisting of equal parts of methanol and *tert*-butyl alcohol (TBA) to total 5.5% alcohol.

Anafuel Unlimited (now American Methyl) also received a waiver for its proprietary fuel, Petrocoal. This product is a combination of methanol, C_4 alcohols, and a proprietary corrosion inhibitor in unleaded gasoline. The waiver allows up to 12% (by volume) methanol, up to 6% C_4 alcohols, and no greater than 15% total alcohol. The ratio of methanol to C_4 alcohols may not exceed 6.5 to 1.

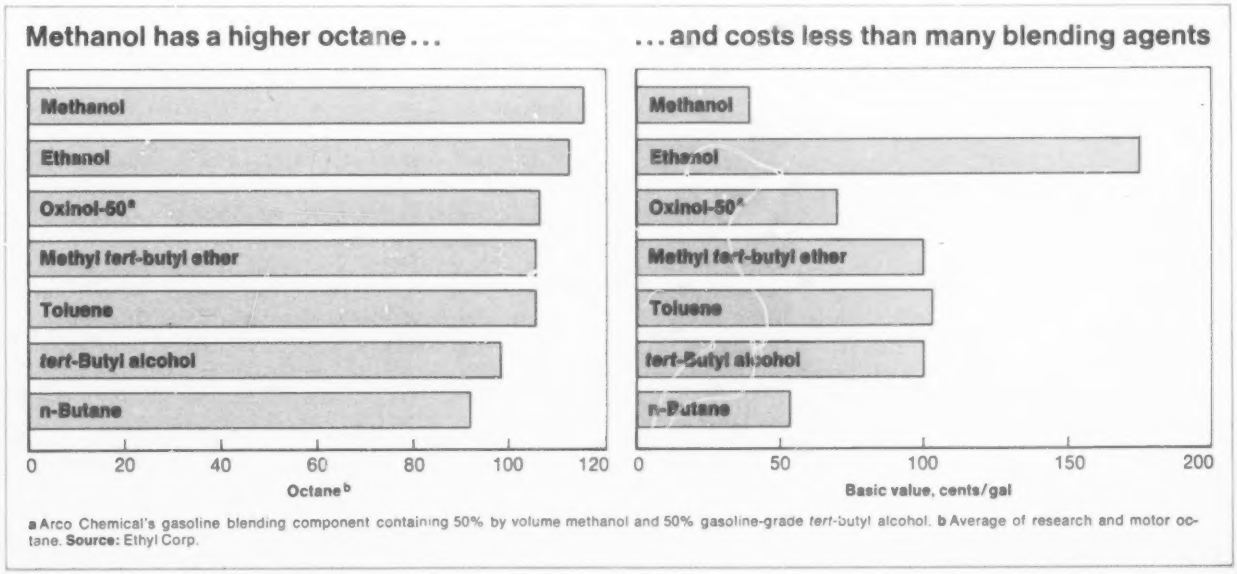
Earlier this year, EPA formally issued a notice that it was considering revoking the Petrocoal waiver because of its concern about evaporative emissions. This is a first-of-its-kind step for EPA, which was pressured by, among others, the auto companies through the Motor Vehicle Manufacturers Association.

It may take a long time before the legal knots of the Petrocoal waiver revocation are untied. Meanwhile, Petrocoal sales have been hurt by the publicity. That, in turn, hurts blended methanol volumes moving into the fuel market, because Petrocoal is one of the sales leaders.

The other sales leader is Oxinol 50, Atlantic Richfield's blending agent containing half methanol and half gasoline-grade TBA, or GTBA. Arco received its EPA waiver for Oxinol in 1981. Neither the methanol nor the GTBA may exceed 4.75%, and the ratio of the two products must be 1:1. The waiver also stipulates that total oxygen content may not exceed 3.5%, which makes it comparable to that of gasohol (10% ethanol and 90% unleaded gasoline).

Of the methanol waiver requests that were denied, the most surprising was Du Pont's. The company applied for a waiver that would permit blends of up to 3% methanol in gasoline, with or without a cosolvent. EPA denied the request because of inadequate emissions data.

However, Du Pont's application also received stiff opposition from the auto industry and California. Their concerns: corrosive effects on engine and fuel system parts, escaping volatile methanol vapor, increased



a Arco Chemical's gasoline blending component containing 50% by volume methanol and 50% gasoline-grade *tert*-butyl alcohol. b Average of research and motor octane. **Source:** Ethyl Corp.

Octane improvement costs can be negative with methanol

Cents per octane-number-barrel[a]	Volume, %	Octane improvement costs: Unleaded regular	Unleaded premium	Leaded regular
Ethanol at $1.76/gal	10.0%	155.4	177.6	201.8
5 cents/gal gasohol subsidy	10.0	79.8	88.2	105.9[b]
10 cents/gal gasohol subsidy	10.0	4.3	−1.2	10.0[b]
Ethanol at $1.76/gal	5.0	173.9	195.0	231.4
Tert-butyl alcohol at $1.00/gal	16.0	81.2	114.2	66.1
Tert-butyl alcohol at $1.00/gal	8.0	88.5	125.5	72.0
Oxinol 50[c] at 70 cents/gal	9.6	5.4	0.0	9.7
Oxinol 50[c] at 70 cents/gal	4.3	31.0	30.6	37.3
MTBE at $1.00/gal	11.0	45.1	49.0	41.7
MTBE at $1.00/gal	4.0	48.8	52.6	45.2
Toluene at $1.05/gal	4.0	48.6	53.7	44.0
Methanol at 40 cents/gal	5.0	−19.0	−17.2	−29.2
Methanol at 50 cents/gal	5.0	−0.7	0.5	−2.3
Methanol at 60 cents/gal	5.0	17.5	18.1	24.7
Methanol at 70 cents/gal	5.0	35.8	35.8	51.6

a The cost required to increase 1 barrel of gasoline by one octane number. b Assuming gasohol subsidy applied to leaded gasoline. c Arco Chemical's gasoline-blending component containing 50% by volume methanol and 50% gasoline-grade *tert*-butyl alcohol. **Source:** Ethyl Corp.

evaporative emissions, and increased aldehydes in the exhaust.

Du Pont started working on a new formulation and collecting data for a new waiver request. Industry insiders speculated that Du Pont would put its application on hold until the Petrocoal waiver revocation issue was settled. But the company submitted its new waiver request to EPA last week.

Industry insiders were right about one thing, however. As they suspected, the waiver request calls for blending up to 5% methanol in unleaded gasoline, with a minimum of 2.5% cosolvent alcohol. The cosolvent, says Du Pont, could be ethanol, propanols, or butanols. The blending agent also would contain a new Du Pont corrosion inhibitor.

It appears, then, that Du Pont soon will join Arco and American Methyl in fighting for methanol blends. They can use all the help they can get, as excessive blending of methanol above allowable limits has led to a rash of consumer problems and legal action in several states. In most cases, the illegal blends were marketed by blenders and retailers rather than by refiners.

But the outbreak of horror stories that followed these events tarred the good guys along with the bad. And antimethanol advertising by several oil companies, including Amoco and Marathon, hurt sales of even properly blended methanol. Arco has counterattacked with an advertising campaign of it own, extolling the virtues of its Oxinol-gasoline blends.

Many of the performance problems associated with methanol blends can be solved with technology. But monitoring improper blending can't be, and it may be the toughest problem of all.

All U.S. car manufacturers have approved ethanol blends up to 10%; that is, gasohol. But they hedge when it comes to methanol blends. Most 1984 owners' manuals caution against using methanol-gasoline blends. Some have warned that certain levels of methanol may void warranty coverage.

Chrysler seems to be the most concerned. Since it is the only company to offer a five-year, 50,000-mile warranty, it warns against using gasoline with any amount of methanol in it and says that using it could void the warranty. Chrysler is anti methanol blends even when a cosolvent is used.

General Motors, however, indicates that up to 5% methanol with cosolvent may be acceptable. Ford advises that methanol-gasoline blends "may be injurious to the fuel system."

This concern on the part of auto companies, coupled with the outbreak of illegal overblending, has spurred a move toward pump labeling laws. Label advocates say that consumers should know what they are buying before it is pumped into their tanks.

Responsible marketers of methanol blends agree. Wayne D. Kuhn, Arco's vice president for oxygenated fuels, says that the industry must accept some standards for proper blending. "Indiscriminate blending doesn't help the industry," he says.

To help define these standards, producers and marketers of oxygenated fuels have formed the Oxygenated Fuels Association. The association supports efforts to develop effective label rules for pumps.

Properly blended, methanol in gasoline has several advantages. It can reduce particulate emissions, sulfur levels, hydrocarbon and carbon monoxide emissions, and cut NO_x levels. It also has a high octane value (116 vs. 87 for most unleaded regular gasolines).

Methanol has some attractive economics in its favor, too. Unlike ethanol, which can't make it into gasohol without state and federal tax subsidies, methanol can stand on its own feet economically. Even considering its energy content, which is lower than gasoline, methanol at 42 cents per gal works out to about 68 cents per gal as a gasoline extender, on a Btu-equivalency basis. Compared to 82-cent gasoline at the refinery, it's easy to see why overblending is profitable, even if selling methanol isn't. Additional value has to be credited to methanol for its higher octane rating.

Refiners will be increasingly hard-pressed to find additional octane. As older cars on the road are replaced by new ones that require unleaded gasoline, leaded gasoline will become less of a factor in the market. Dan Lundberg, respected publisher of the *Lundberg Letter*, says that, even without the accelerated lead phasedown that EPA is considering, leaded gasoline will represent only 20% of the market by the early 1990s. Its share was 46% last year and 66% in 1978.

This change alone will require a two-octane-number increase in the base gasoline pool. Refiners will be hard-pressed to meet it. They will be looking at all of their options, including octane extenders.

George H. Unzelman, technical director of Ethyl's chemical division, says that, from an economic standpoint, methanol looks very attractive as an octane extender. Unzelman has determined costs to raise 1 barrel of gasoline by one octane number, which he

calls the cost per octane number barrel (ONB). He says that, with methanol at 50 cents per gal, octane improvement costs are about zero when 5% methanol is used in gasoline. If methanol costs less than 50 cents per gal, which it does, octane improvement costs are actually negative, says Unzelman.

Methanol's octane economics are much better than those of ethanol (even with a 10% gasohol subsidy), TBA, MTBE, or toluene. Refiners that can, of course, will rely on processing to get their additional octanes. They have several options, but the two major units are the fluid catalytic cracker and the naphtha reformer. Not all refiners have the capability, however, to increase process severity.

One factor that doesn't show up in Unzelman's methanol ONB costs is the penalty for methanol's lower energy content, or Btu value. The refiner or blender of methanol and gasoline does get the full benefit of methanol's lower ONB costs, but the real value to the motorist, says Unzelman, is something less. With the energy penalty, the motorist pays more for the octane improvements afforded by methanol. He says this penalty ranges from 40 cents to 60 cents per ONB.

On a straight dollars-per-barrel basis, methanol has a ratio of 1 to 2 cost advantage over unleaded gasoline. It is expected to maintain that advantage for some time. However, Arco's Kuhn cautions about putting too much emphasis on methanol economics without figuring in the impact of cosolvent costs. He points out that methanol will not be used in commercial systems without a cosolvent; thus the cost of the cosolvent, as well as methanol, influences the economics of the mix.

Methanol blended with unleaded gasoline has advantages and disadvantages. But even most impartial observers agree that the advantages far outweigh the disadvantages. The one thing that blended methanol doesn't have that neat methanol does have is the problem of which to develop first, the proper auto engine or the fuel distribution system. For this reason alone, some methanol producers think that the market for blended methanol is worth pursuing. They feel that the blend market can serve as a bridge to an eventual neat methanol fuel market once all of its problems are overcome. During this transition period, methanol blends will grow and will provide the economic incentive needed to develop a network of methanol service stations.

Not everyone, however, believes that developing a methanol blend market is worth the effort. Daniel Sperling, professor of civil engineering and environmental studies at the University of California, Davis, is one of these. He says that pursuing a methanol blend market "diffuses and dissipates" the larger effort of the entire industry to crack the neat methanol market.

He calls the blend route a "segmented" marketing strategy that doesn't generate any marketing expertise necessary for the neat methanol assault. It doesn't help get the distribution infrastructure in place, says Sperling, and it doesn't build the political and economic constituencies that could help develop and support a neat methanol market.

One area of the country that has forgone the blend route in favor of neat methanol is California. Methanol blending has remained "off limits" in California, says Charles R. Imbrecht, chairman of the California Energy Commission. But that is because the state's air quality regulations limit gasoline vapor pressure and it is difficult to meet these limits with methanol-gasoline blends. If a solution could be found to the vapor emissions problem, methanol-gasoline blends would receive "new consideration" as a way to create an initial market for methanol in California, says Imbrecht.

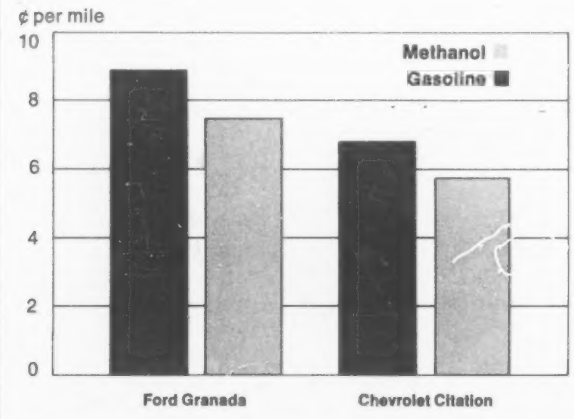
Meanwhile, state and private agencies are accumulating a lot of experience and data with neat methanol vehicles. There is a higher concentration of methanol-

Several pieces of legislation concerning methanol have been proposed in Congress

Bill and sponsor	Contents
H.R. 4855 Rep. Philip R. Sharp (D.-Ind.)	Federal fleets Reduce tax from 9 cents to 4.5 cents per gal Vehicle tax credit Buses Methanol commission
H.R. 5075 Rep. James T. Broyhill (R.-N.C.) Rep. Richard L. Ottinger (D.-N.Y.)	Federal fleets with replacement timetable DOE study Buses
H.R. 4975 Rep. Cecil L. Heftel (D.-Hawaii)	Reduce tax from 9 cents to 4.5 cents per gal
Amendment to Senate tax package Sen. John H. Chafee (R.-R.I.)	Reduce tax from 9 cents to 4.5 cents per gal

Source: Celanese Chemical

Methanol shaved fuel costs in California test

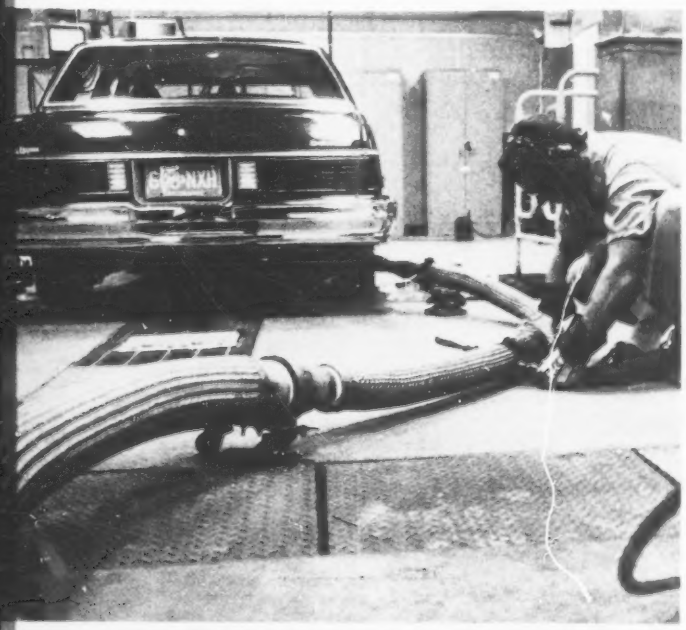


fueled vehicles on the road in California than anywhere else in the world, says Imbrecht. More than 25 service stations now dispense methanol throughout the state and more are planned. California alone is using about a million gallons of methanol per year and is accumulating neat methanol operating experience at the rate of more than 10 million miles annually.

In 1979, the state legislature appropriated $10 million to investigate alternative fuels. With some of this money, the California Energy Commission has been operating three test fleets. Fleet I contains 12 1980 Ford Pintos, four of them retrofitted for neat methanol. Fleet II has 40 1981 Volkswagen sedans and pickups. These include 11 methanol Rabbits and eight methanol pickup trucks—the first U.S. factory-produced fleet with state-of-the-art methanol fuel injection engines. Fleet III, in which there is an unusual amount of interest, contains 55 1981 Ford Escorts, with 40 of them station wagons engineered and modified to use 94.5% methanol.

This third fleet, operated by the Los Angeles County mechanical department, already has shown that carbureted methanol vehicles can provide reliable service to fleet operators. It also has shown lower NO_x, hydrocarbon, and carbon monoxide emission levels on a gram-per-mile basis with no sacrifice in fuel economy. In fact, fuel mileage was slightly better with neat methanol than with regular unleaded gasoline.

Based on the success of Fleet III, California issued a request for 500 1983-model methanol cars. Ford, the only bidder, supplied 500 Escorts, which are now in operation. They are the largest methanol test fleet in the world.



Du Pont analyzes exhaust emissions in its research on use of methanol in gasoline. Here a technician connects hose used to carry exhausts from auto to analytical equipment

Methanol capacity: plenty, even with two plants closed

Thousands of metric tons per year	Methanol capacity
Air Products & Chemicals/Pensacola, Fla.	180
Allemania Chemical/Plaquemine, La.	390
Arco Chemical/Channelview, Tex.	600
Borden Chemical/Geismar, La.	570
Celanese Chemical/Bishop, Tex., and Clear Lake, Tex.	450 (690)[a]
Du Pont/Beaumont, Tex.	675
Deer Park, Tex.	600
Georgia-Pacific/Plaquemine, La.	360
Getty Oil/Delaware City, Del.	300
Monsanto/Texas City, Tex.	300
Tenneco/Houston	(390)[a]
Tennessee Eastman/Kingsport, Tenn.	195
TOTAL	**4620**

a Shut down. Not included in total.

The state has other neat methanol tests in progress, including heavy vehicles and transit buses. But one of the largest private methanol fuel programs is run by Bank of America. What makes the bank program stand out, among other things, is that it involves both neat methanol and methanol blends.

Bank of America began investigating alternative fuels in 1980 to protect its own huge vehicle fleet against another fuel shortage. Now it has accumulated more than 9 million miles of fleet experience with methanol. The corporation has a fleet of 2400 vehicles, and 292 of them have been converted. Its neat methanol fleet has 42 standard-compression General Motors vehicles and 250 higher-compression Ford vehicles. All of the remaining gasoline vehicles receive either 4% or 5% methanol blends (5% in San Francisco; 4% elsewhere).

Bank of America vice president Merle R. Fisher says that the bank tackled problems of materials compatibility, fuel contamination, and excessive engine wear head on. As a result, many of its cars have more than 50,000 miles on them and are still going strong, he says. By comparison, unprotected engines of the U.S. Postal Service had a useful life of only 15,000 miles.

Many fuel experts agree with the California enthusiasts who say that neat methanol has many advantages. It has greater thermal and fuel efficiency at higher compression ratios, more power than straight gasoline, less toxic emissions, is cooler and leaner burning, and probably has better fuel economy than regular gasoline.

To expand neat methanol's use and availability as a fuel to the country at large, Donald E. Petersen, president of Ford Motor, has suggested, on the automotive side, a four-step, phase-in program. It would grow, he says, from the current experimental fleet level to a "limited fleet" of 5000 to 10,000 vehicles annually in Phase II. In Phase III, annual volume would increase to 30,000 to 50,000 and the market focus would expand to regional sales. Phase IV would be full

commercialization—nationwide, unrestricted sales of 250,000 to 350,000 vehicles annually.

But Petersen says that the auto companies would be foolhardy to move even into Phase II without assurance that subsequent phases will follow on schedule. And free market forces alone won't guarantee it, he adds.

His suggestion: more government action. A lot of neat methanol fans agree with him. California's Imbrecht, for instance, says that the state is approaching the limit of what it can spend on methanol development. He thinks that what's needed is a wider commitment on a national level to continue the government-industry effort that was started in California.

A flurry of methanol-related action is, in fact, taking place in Washington. Several pieces of methanol-related legislation are now before Congress. Some propose mandating methanol cars for federal fleets. Others suggest that methanol transit buses be bought with federal funds. Still others grant tax breaks for methanol fuel.

On the executive side, an interagency methanol working group has been formed to study just what the federal government can do to stimulate methanol's market growth in fuels. Already, for instance, EPA is formulating regulations for methanol vehicle emissions.

Some methanol producers contend that methanol's path into the fuel market runs through EPA's door. That is the agency that makes the regulations and hands out the exemptions.

It also is the agency that is considering banning or sharply reducing the amount of lead in gasoline. EPA is considering two options: an outright ban on lead antiknock agents, or the "low-lead option," which would reduce lead levels to 0.1 g per gal by 1988. The present allowable limit is 1.1 g per gal.

Methanol blenders are happy about the prospects. If either one happens, it will have a significant impact on alcohol fuels, says Arco's Kuhn.

Lower lead levels also will help methanol-based octane enhancer MTBE. With this compound, many of the problems associated with blended methanol don't surface. It causes no problems with the fuel or distribution system. MTBE's big drawback, however, is a shortage of precursor isobutylene. An estimated 240,000 metric tons of methanol went into the fuel market via MTBE last year. This could increase to about 340,000 metric tons by 1986, according to DeWitt's Crocco, to get the additional octane that will be needed. If there is enough available isobutylene, that volume could be higher. There certainly is no shortage of methanol to hold down MTBE output.

Another path for methanol to follow into the fuel market is Mobil's methanol-to-gasoline process. This process yields a high-octane, unleaded gasoline directly from methanol. The product from the process would be compatible with existing refining and distribution systems as well as existing cars, thus avoiding all the problems associated with methanol blends and neat methanol. But the economics aren't right for the U.S.

However, in New Zealand, which imports much of its petroleum, the first commercial methanol-to-gasoline plant will be on stream next year. The 12,500 bbl-per-day unit will be supplied by a new 1.5 million metric-ton-per-year methanol plant also being built in New Zealand.

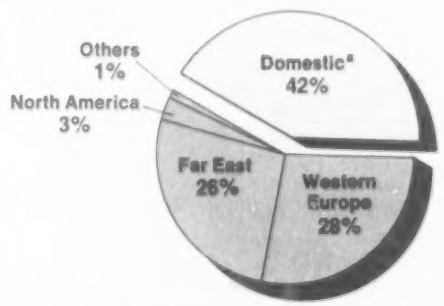
But no matter how hard or how many ways metha-

World will add 8.8 million metric tons of methanol capacity in three years . . .

Thousands of metric tons	New methanol capacity 1983	1984	1985
U.S.	**1080**		
Arco Chemical	600		
Tennessee Eastman	180		
Getty Oil	300		
Middle East/Africa	**660**	**660**	**660**
Saudi Arabia	660		660
Libya		330	
Bahrain		330	
Asia/Oceania	**390**	**858**	**1830**
New Zealand	390		1500
India		48	
Malaysia		660	
Burma		150	
Indonesia			330
Eastern Europe	**0**	**825**	**1485**
Soviet Union		825	825
East Germany			660
Western Hemisphere		**390**	
Trinidad		390	
TOTAL NEW CAPACITY	**2130**	**2733**	**3975**

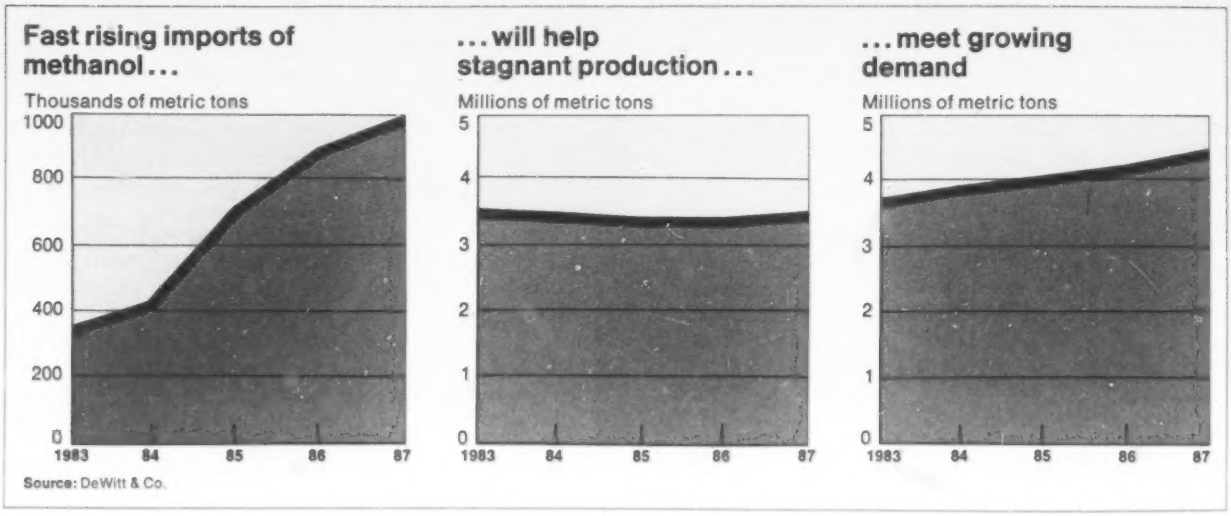
Note: Total global capacity at end of 1982 was 14,490 million metric tons, and at end of 1985 will be 23,328 million.

. . . and more than half of output from new capacity will be exported



1986 projected methanol destinations for new producers

[a] Use in producer country. **Source:** DeWitt & Co.



nol producers try to push their product into the fuel market, some experts insist that really large-volume shipments will escape them until the price of crude oil increases substantially. If that is true, U.S. producers will have to live with their overcapacity a few years longer.

And they will have to face the prospect of more import competition as new capacity comes on stream in resource-rich areas. Crocco estimates that, in a three-year time span, 1983–85, 8.8 million metric tons of new capacity will come on stream worldwide. More than 1 million metric tons of that already came on stream in the U.S. last year. The rest has gone and is going up in natural gas-rich areas in the Middle East, Asia, and Eastern Europe, particularly the Soviet Union. Saudi Arabia will be the big methanol force in the Middle East.

That 8.8 million metric-ton capacity addition is a hefty 61% of 1982's nameplate capacity and about 75% of last year's world methanol consumption. In just three years, world methanol capacity will have jumped from 14 million metric tons to more than 23 million metric tons. Crocco expects about 2 million metric tons of old capacity to be shut down, leaving a net of 21 million metric tons of capacity for the world to consume.

A lot of that new capacity will have little domestic demand, and the new producers will export much of their output. Crocco estimates that, of the 8.8 million metric tons of capacity coming on stream, 58% of it, or 5.1 million metric tons, will be available for export.

Western Europe will feel the biggest impact from this low-priced methanol, and Asia won't be far behind. Japan, a high-priced methanol producer, has been shutting down plants and switching to imports, especially from Saudi Arabia.

U.S. methanol imports will increase from last year's 300,000 metric tons to about 1 million metric tons in 1987. Most of this will be sourced closer to home, from Canada and Trinidad, but that won't make it any more welcome. U.S. methanol capacity, not even counting two plants that are shut down, is 4.6 million metric tons, much more than the 3.8 million metric-ton demand that is expected this year.

In a left-handed way, however, the imported methanol that is certain to come into the U.S. could help the U.S. methanol fuel market. It will be inexpensive, which is always helpful in opening up new markets. Methanol imported for fuel faces no U.S. duty, whereas methanol for chemicals has an 18.6% tariff. The difference in methanol tariff rates could be meaningless, however, for Trinidad and Canada if Trinidad is able to keep the duty-free status it enjoys under the generalized system of preferences and if Canada and the U.S. negotiate duty-free trade in petrochemicals, which has been proposed.

But, whether domestic or imported, the only sponge big enough to soak up the excess methanol is the fuel market. And this market involves more than just substituting for gasoline. Methanol has been suggested for a lot of fuel uses, from blending with or replacing diesel, to mixing with coal in a slurry. The most likely large-volume use, other than in gasoline, is as a fuel for stationary combustion turbines in peak load operations. This market, too, is hard to crack because utilities are reluctant to rely too heavily on methanol. They require a reliable and guaranteed source. Large volumes would be involved. Brownouts would be the penalty for slipups. Besides, the stabler price outlook for oil-based fuels has erased a lot of utility interest, just as it has in the gasoline market.

Crude oil prices are the key. They will determine the short-term future of methanol in fuel markets of all kinds. If crude prices remain low and stable, methanol will have to fight and scratch for every inch it gains along the road to the fuel market. If, for some reason, crude prices escalate, as they eventually must, then methanol's potential in fuel "boggles the mind," as Crocco puts it.

Meanwhile, U.S. methanol producers will have to live with overcapacity, low prices, little or no profit, and not much hope for relief until later in the 1980s. □

outstrip the rise of prices in general. In 1982, for example, the index of medical care prices rose 12%, whereas the Consumer Price Index increased just 6.0%. In 1983, the increases were 8.7% and 3.0%, respectively. And in the first quarter of this year, medical care prices rose 4.2%, compared to a mere 1.9% for the Consumer Price Index.

In response to hospitals' new cost consciousness, suppliers are scrambling to develop products that hospitals will buy because they reduce costs. The new focus is evident in both therapeutics and diagnostics. Abbott Laboratories, for instance, which gives much of the credit for its strong 1983 and first-quarter 1984 earnings performance to awareness of the new market realities, last month signed an agreement with Eli Lilly & Co. under which Lilly will offer its line of intravenous (IV) drugs, including injectable antibiotics, in an IV drug admixture system designed for intermittent administration of drugs that do not have long stability in solution.

Separately, Abbott also is marketing a system with which patients administer pain-relieving drugs by themselves intravenously in small, intermittent doses. Again, the company asserts, the system will cut hospital labor costs and add to drug use effiency.

In diagnostics, Abbott is introducing automated, high-volume clinical analyzers that it says will simplify test procedures, improve laboratory productivity, give more precise results in some cases, and make it possible for small and medium-sized hospitals to run tests on site that normally are sent to larger, higher-volume laboratories.

Other companies have moved to develop cost-efficient drug delivery systems as well. SmithKline Beckman recently received Food & Drug Administration approval to market Monocid, a cephalosporin antibiotic that can be injected just once daily instead of the typical three to four times a day. SmithKline says this should save hospitals money by reducing drug and administration costs, freeing nurses for other duties, and making it possible in some cases to release patients earlier to outpatient or home treatment.

In one study of four hospitals in Philadelphia, the difference in expenses between using Monocid and other cephalosporins was such that if the study institutions had used nothing but Monocid, they would have saved an average of $5.40 per patient day of therapy on antibiotic materials and labor, the company says, adding up to $103,000 per hospital per year on average.

And Baxter Travenol has been signing up other drug makers to package their cephalosporins in premixed form in the company's plastic container system. Baxter Travenol has such agreements with SmithKline for Ancef, with Merck & Co. for Mefoxin, with Hoechst-Roussel Pharmaceuticals for Claforan, and, most recently, with Fujisawa SmithKline Corp. (a joint venture of Fujisawa Pharmaceutical and SmithKline) for Cefizox. Approval from FDA is expected by the end of 1984, Baxter Travenol says.

Such development and marketing efforts are typical of the hospital supply industry's strategy for dealing with a market that has turned a sharp corner. It isn't that companies anticipate a moribund business concerned with nothing but reducing costs in the future; the general aging of the population is expected eventually to offset such effects. But they know that strategic changes are called for.

"Health care will continue to be a good business, but only for those manufacturers that help solve the cost problem," remarks Robert A. Schoellhorn, chief executive officer of Abbott Labs, in forecasting an 18% earnings increase for his company in the second quarter. "These are manufacturers whose products and services reduce overall health care costs, who provide the technology that makes the health care system itself more productive, and who can achieve the internal efficiencies necessary to stay competitive in an increasingly price-sensitive market."

David Webber, New York

Middle East will become major ethylene supplier

The U.S. will continue to be a major source of ethylene-based chemicals on world markets during the next several years. By 1990, however, it will be nudged out of its current position of dominant supplier by producers in the Middle East, primarily those in Saudi Arabia. On the other hand, the U.S. will retain its role as premier supplier of propylene derivatives.

These are among the conclusions presented recently by John A. Collins, head of the petrochemicals division of London-based Shell International Chemical Co., to the CHEMRAWN III conference in The Hague. CHEMRAWN, an acronym for Chemical Research Applied to World Needs, is an ongoing activity of the International Union of Pure & Applied Chemistry.

The way Collins sees it, U.S. net exports of ethylene-derived products in 1990 will amount to 2.20 billion lb ethylene equivalent. That will represent a 47% decline from the 4.18 billion lb in net exports in 1982. Over the same time span, Middle Eastern countries will swing from being net importers of 660 million lb to net exporters of 2.97 billion lb. Canadian net exports, meanwhile, could surge 500% from 110 million lb to 660 million lb.

Among the other trading areas, Western Europe likely will become a net importer of 1.2 billion lb ethylene equivalent in contrast to its net exports of 990 million lb in 1982. Net exports from Eastern Europe likely will remain steady at 440 million lb, and imports by Asian countries other than Japan are expected to continue unchanged at 2.64 billion lb. Imports into Japan, however, may rise 600% from 220 million to 1.54 billion lb.

Anticipated changes in the global trade balance of ethylene derivatives reflect changes likely to occur both in ethylene production and consumption totals. Collins looks for an increase of some 32% from about 75 billion lb in 1982 to 99 billion lb in 1990, on the assumption that overall production and consumption will remain essentially in balance. There will be variations, of course, at local levels.

Middle East will produce 6.2 billion lb of ethylene by 1990

Billions of lb	Capacity 1982	Capacity 1990	Production 1982	Production 1990	Consumption 1982	Consumption 1990
ETHYLENE						
U.S.	38.15	38.19	24.66	31.46	21.69	29.26
Western Europe	34.72	32.03	22.44	24.86	21.69	26.40
Japan	12.34	9.86	8.23	9.24	8.23	10.89
Middle East	0	7.39	0	6.16	0	3.74
Others	26.93	35.73	19.45	27.28	23.94	28.71
TOTAL	**112.14**	**123.20**	**74.80**	**99.00**	**75.55**	**99.00**
PROPYLENE						
U.S.	—	—	12.76	19.45	10.99	17.60
Western Europe	—	—	12.76	14.87	12.62	15.40
Japan	—	—	5.50	7.44	5.29	7.92
Middle East	—	—	0	1.14	0	1.76
Others	—	—	9.68	14.30	11.80	14.52
TOTAL	—	—	**40.70**	**57.20**	**40.70**	**57.20**

Source: Shell International Chemical Co.

In the U.S., for instance, output is forecast to expand 28% to 31.5 billion lb, whereas domestic consumption will be 35% higher at 29.3 billion lb. West European production likely will move up 11% to 24.9 billion lb, but the increase won't be sufficient to meet the expected 1990 requirement of 26.4 billion lb, 22% greater than in 1982.

Japan's ethylene generation of 9.24 billion lb, although 12% more than in 1982, will fall short of the anticipated consumption of 10.9 billion lb, 32% more than in 1982. In the other regions of the world excepting the Middle East, 1990 ethylene production will amount to 27.3 billion lb, a 40% increase, and consumption will be 28.7 billion lb, 20% ahead of 1982.

But it will be in Saudi Arabia where production and consumption changes will be the greatest in the near term. In contrast to 1982 when there was no ethylene output capability there, 6.16 billion lb is expected in 1990, 6.2% of the world total output in that year and 2.42 billion lb more than local ethylene demand. Key is the plentiful availability of low-cost ethane extracted from natural gas that now is flared.

The U.S. has relied on natural gas-derived ethane as the main source of ethylene. But as Collins points out, this "has at least reached a plateau and could even decline. Any increased [ethylene] production will have to be based on liquid feedstocks. In contrast," he adds, "West Europe and Japan have had to rely almost entirely on cracking liquid feedstocks, predominantly naphtha."

For Europe, the situation will be partly alleviated with the startup next year of a cracker at Mossmorran, Scotland, using ethane from North Sea gas. The 1.1 billion lb-a-year output will be shared with Exxon and Shell, who are funding the project jointly. "With ethylene production at Mossmorran based on ethane effectively replacing a similar amount of production from naphtha, and with increased flexibility built into many existing crackers so that they can handle liquefied petroleum gas (LPG), gas oil, or heavier feedstocks, naphtha demand in Western Europe will almost certainly decline," Collins maintains.

Liquid feedstocks have the edge over ethane, however, in that cracking yields propylene as a coproduct of ethylene. The actual amount varies with the feedstock and the cracking conditions. Thus, "the term 'propylene capacity' is somewhat elastic, and the concept can be even misleading," Collins notes.

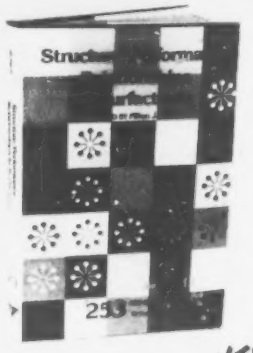
Also, the volume of propylene produced during ethylene manufacture is insufficient to fulfill the needs of the chemical industry, and must be augmented by product recovered from oil refinery streams. "The greatest use of refinery-derived propylene occurs where ethylene manufacture is based on ethane cracking," Collins adds, "and where gasoline requirements necessitate significant catalytic cracking of heavier [grades of oil] products. It is not surprising that in the U.S. usage of refinery propylene for petrochemical purposes exceeds that of material from naphtha cracking."

He anticipates global propylene production will rise nearly 41% from 40.7 billion lb in 1982 to 57.2 billion lb in 1990. During those years, he projects U.S. demand will grow 60% to 17.6 billion lb. Next in terms of demand increase will be Japan (rising 50% to 7.92 billion lb), and Western Europe (22% to 15.4 billion lb). Propylene use throughout the rest of the world might expand 23% to 14.5 billion lb. The Middle East, which produces or consumes hardly any propylene right now, might need 1.76 billion lb by 1990, most of it recovered from refineries.

The U.S. will maintain its dominance as a supplier of propylene derivatives on world markets. In terms of propylene equivalents, exports in 1990 are projected to reach 2.2 billion lb, 43% more than in 1982. Canada and Eastern Europe will continue to be net exporters, probably at their 1982 levels (550 million lb for Canada and 330 million lb for the East bloc). Western Europe will move from being a net exporter (220 million lb in 1982) to a net importer (330 million lb) in 1990, as will Japan (220 million lb exports in 1982 to 550 million lb imports in 1990). Imports into Central and South America could decline 50% to 660 million lb. Imports into the Middle East, Africa, and other Asian countries likely will remain at their 1982 levels (220 million lb each for the Middle East and Africa, 1.10 billion lb for Asia).

"It has been postulated," Collins notes, "that with demand for propylene derivatives growing faster than for ethylene derivatives, this could upset the ethylene/propylene balance. Although the demand growth rate for propylene derivatives is some 20 to 25% more than the corresponding rate for those based on ethylene, it should not be overlooked that worldwide production and chemical demand for propylene in 1982 was less than 55% that for ethylene. Notwithstanding the growth rate differences, in 1990 it still will be less than 60% that for ethylene. Consequently, insurmountable problems in this decade need not be expected." □

Structure/ Performance Relationships in Surfactants



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cy in terms of research scaleup and technology transfer, the job would be better served by having an organization devoted just to that. We certainly have fallen behind other countries in those sectors. It could be a good investment on the part of the government. And I wouldn't be surprised if that view is now shared by many others in the scientific community."

NSF's Wilson is more cautious. "If the economically competitive disciplines continue to get modest increases," he says, "I would think any talk of establishing a special technology foundation would be muted. But if a much higher percentage of the NSF budget would go into engineering, I think you'd hear a groundswell of opinion to get the technologists off our backs." □

Budgets set for many federal R&D agencies

A number of federal agencies, including four that support R&D, find themselves in the almost unbelievable position of knowing three months ahead of time just how much money they will have to spend in the coming fiscal year. This represents quite a turnaround by a Congress that just two years ago couldn't manage to set final budget figures until three months after the Oct. 1 start of the fiscal year.

Among those lucky agencies is the National Science Foundation. Congress set its total budget at $1.5 billion, the amount requested by the Administration and approved by the Senate and $2 million more than the House-passed figure. But although funding for research and related activities will be $1.3 billion—only $6 million less than requested and $161 million more than is available this year—Congress did a lot of adding and subtracting in reaching that figure.

Computing accounted for most of the additions. Congress doubled the $20 million request for advanced scientific computing, that is, supercomputers, and increased about 50% the $6 million request for information sciences; the $4 million request for automation, instrumentation, and sensing systems; and the $3 million request for intelligent systems computer research. (The first addition was made by the House; the last three by the Senate; and all were accepted by the conferees that worked on the bill.)

To keep the books somewhat in balance, Congress told NSF that it must cut $36.3 million from the research and related activities budget. It can do so anywhere it wants as long as the money doesn't come out of any of the above activities or the biological, behavioral, and social sciences directorate's budget.

NSF won't have to make any cuts at all in its science education activities, inasmuch as it will have 15% more money to spend than it actually wanted, or $87 million more, to be exact. These extra funds are to be used to restore the number of new graduate fellowships to the 1984 level of 600—NSF had intended to have 550—while at the same time increasing the annual stipend to $11,000 and the cost-of-education allowance to $6000.

The Environmental Protection Agency certainly won't have to do any belt tightening either. In fact, its only problem may be spending its money fast enough, particularly in the research area. Congress increased funding for extramural R&D 35% to $193 million. The Administration had wanted a mere 15% increase. Among the additional monies that EPA will have to spend are $5 million for health effects research, $4 million for hazardous waste control technology, $3.5 million for exploratory research grants and centers, $2 million for indoor air pollution research, and $1 million for pesticide research.

Funding for EPA's salaries and expenses account, which funds in-house research, will be $656 million. That figure is 14% higher than what is available this year and 3% more than the budget request. Congress suggests that the increased funding be used for hiring new employees to work on hazardous waste regulation, program implementation, and research; biological assessment of toxic chemicals; and evaluation and regulation of toxic chemicals.

Congress sets its own funding priorities

$ Millions	1985 Appropriation	1985 Request	1984	% change 1984–85
NASA	**$ 7,491.4**	**$ 7,491.4**	**$ 7,197.5**	**4%**
Space-flight control and data communications	3,601.8	3,600.3	3,791.6	−5
R&D	2,422.6	2,400.1	2,011.9	20
Research and program management	1,317.0	1,331.0	1,238.5	6
Facilities	150.0	160.0	155.5	−3
Energy	**3,790.8**	**3,871.7**	**3,479.6**	**9**
Energy supply R&D	**2,027.2**	**2,039.7**	**2,012.6**	**7**
Nuclear	626.3	623.0	674.6	−7
Supporting research and technical analysis	481.0	479.6	395.1	22
Fusion	440.1	483.1	470.7	−6
Environment	229.7	226.2	216.0	6
Solar	179.4	163.6	181.6	−1
Electric energy systems and storage	38.6	37.1	44.2	−13
Geothermal	32.1	27.1	30.4	6
Weapons R&D	**1,036.0**	**1,085.2**	**825.8**	**25**
General science and research	**727.6**	**746.8**	**641.2**	**13**
NSF	**1,501.8**	**1,501.9**	**1,320.3**	**14**
Research and related activities	1,301.9	1,308.2	1,140.3	14
Antarctic program	110.1	115.1	102.1	8
Science education activities	87.0	75.7	75.0	16
Scientific activities overseas	2.8	2.9	2.9	−3
EPA	**1,296.8**	**1,198.7**	**1,111.5**	**17**
Salaries and expenses[a]	656.3	639.3	574.9	14
Abatement, control, and compliance	447.5	396.0	393.9	14
R&D	193.0	163.4	142.7	35
TOTAL	**$14,080.8**	**$14,063.7**	**$13,108.9**	**7%**

a includes in-house research funding

Funding for the abatement, control, and compliance account, which EPA uses to enforce its regulations, will be almost $448 million, about 14% more than both the request and this year's funding level. Congress directed that state grants programs be increased by at least the following amounts: $7 million for water; $5 million for hazardous waste; $3 million for air; and $1 million each for drinking water, underground injection control, and pesticide enforcement.

Congress increased funding for the Department of Energy's energy supply R&D activities 7% to $2.0 billion, just slightly less than the Administration had requested. However, that doesn't mean that every program is getting an increase over fiscal 1984 funding levels. One that is is basic energy sciences, funding for which will be up 26% to $426 million. Within that category funding for chemical sciences will rise 15% to $95.1 million, and funding for materials sciences will increase 25% to $194 million.

The materials sciences budget will include $11 million for the center for advanced materials at the University of California, Berkeley; $8.9 million for completion of the vitreous state laboratory at Columbia University; and $3 million to continue the national center for chemical research at Catholic University.

Congress' total budget for the Nation Aeronautics & Space Administration is exactly in line with the Administration's $7.4 billion request, including the 20% increase requested for R&D. The $2.4 billion R&D budget, rearranged a bit from the request, includes $150 million for a space station; $195 million for development of a space telescope; and $120 million for the γ-ray observatory. The final version of NASA's R&D budget is in line with the version approved by the House (C&EN, June 18, page 17).

Janice Long, Washington

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